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Marketing Losses of Selected Fruits and Vegetables

At Wholesale, Retail, and Consumer Levels In the Chicago Area

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Marketing Losses of Selected Fruits and Vegetables

At Wholesale, Retail, and Consumer Levels In the Chicago Area

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SUMMARY

The market loss incurred on six major produce items in the metropolitan Chicago area was compiled from July 1966 through November 1969. These data are still valid to show the wholesale (W), retail (R), and consumer (C) losses involved.

Wholesale losses were determined by a simulated retail cull of weekly unit samples obtained from a chainstore distributing center and from an independent street broker. Retail losses were gathered from the in-store cull operations of four stores, two of which were affiliated with the chain distributor and two serviced by the independent wholesale source. Consumer wastes were obtained by simulated consumer tests on produce obtained from the retail displays of the cooperating stores.

Wholesale and retail losses were based upon visible defects and unit discard of the affected item. Consumer examination entailed salvage of edible portions, with waste constituting anything over and beyond normal paring for table preparation. Summary results express the percentage of loss on a waste-weight basis per product by market level for the survey and the relative percentage of contribution of the dominant loss category to its respective market level. The categories consisted of the parasitic loss from fungi, bacteria, and yeasts; nonparasitic losses were physiological and insect loss damage, as well as miscellaneous defects such as freezing, and chemical-induced damage; the physical injury category included mechanical injury and bruising. Summary data are presented in the order of wholesale, retail, and consumer marketing levels, unless noted.

Northwest Red Delicious apples had a percentage loss of 2.9 (W), 2.9 (R), and 2.4 (C). Physical injury, largely bruising, led at all marketing levels, contributing 78, 88, and 49 percent, respectively.

California head lettuce percentage losses were 5.7 (W), 1.7 (R), and 13.9 (C). Physical injury was dominant at the (W) and (C) levels, contributing 62 and 68 percent, while parasitic disease loss was greater at the (R) level, contributing 39 percent.

California navel orange losses were 2.0 (W), 1.6 (R), and 2.2 (C) percent. Parasitic disease problems, mostly green mold rot, dominated at each market level throughout the study, contributing 74, 75, and 95 percent.

Florida Valencia orange losses were 1.4 (W), 0.8 (R), and 3.7 (C) percent; parasitic diseases being the leading loss category, at all levels, contributing 66, 86, and 88 percent.

Peaches sustained losses of 12.3 (W), 5.8 (R), and 10.8 (C) percent. Physical damage was dominant at the (W) and (R) levels where it contributed 77 and 78 percent, respectively; parasitic disease led at the (C) level, contributing 65 percent.

Red River Valley red potato percentage losses were 4.9 (W), 1.0 (R), and 3.7 (C). Physical injury was the chief loss source at all levels, contributing 59, 74, and 42 percent.

California long white potato losses were 2.5 and 2.4 percent for (W) and (C) market levels. Physical injury was the chief cause of loss at the (W) level, contributing 69 percent. Nonparasitic problems, principally greening, were greater at the (C) level, contributing 67 percent.

California and southern grown strawberry losses were 13.5, 5.5, and 22.2 percent. Physical injury, which included soft, leaking, bruised, and cut berries, led at all marketing levels, contributing 61, 71, and 77 percent.

INTRODUCTION

Information on losses sustained by items of produce during their passage through the various marketing channels is of interest and concern to all who are engaged in the complex task of delivering quality fresh produce to the ultimate consumer. Before the publication of a companion study covering market losses for the New York area, by Ceponis and Butterfield (*3*), information on the losses sustained by fresh produce throughout the marketing process has been fragmentary; often obtained by a culling of U.S. Department of Agriculture arrival inspection certificates, or through observations of isolated products within a restricted market context. The only previous publication that attempted to present a coordinated picture of market losses of a relatively broad spectrum of fruits and vegetables was by Miller (*10*)[1], 40 years ago. Rapid advances in growing, harvesting, storing, packing, shipping, and merchandising make a periodic appraisal of the nature and extent of market losses desirable.

This publication details the results of a 3-year survey of losses sustained during the wholesale, retail, and consumer marketing stages of selected fresh fruits and vegetables in the Chicago, Ill., area. Here, "market" loss at wholesale and the retail level refers to those parasitic diseases, nonparasitic disorders, and physical injuries that would encourage rejection of the product by the potential consumer. At the consumer level, this loss consisted of the loss of edible produce resulting from the elimination of objectionable defects. The terms "loss," "shrink," and "waste" are used interchangeably.

A consumer loss, as reported here, is not added onto or a compounded reflection of the wholesale and retail loss. Similarly, neither is the retail loss a reflection of wholesale loss. Each stands alone because the same sample units were not surveyed during marketing.

MATERIALS AND SAMPLING METHODS

The following produce commodities were selected for study.

1. Apples, Red Delicious from the Pacific Northwest.
2. Head lettuce from the Salinas-Watsonville-King City area of California.
3. Oranges, Washington navels from California and Valencias from Florida.
4. Peaches, mostly from southern growing areas, but small amounts were also sampled from eastern and midwestern growing areas.
5. Potatoes, a long white variety from California, and red potato varieties from the North Dakota-Minnesota growing area.
6. Strawberries, both Californian and southern grown.

An adaptation of the Magness-Taylor pressure tester known as the "mechanical thumb," (*18*) a Beckman Expandomatic pH meter, and a Lafayette hand-sugar refractometer were utilized. These determined the firmness, pH, and percent soluble solids, respectively, of the fruits involved in the survey. These findings are presented in the text as "auxiliary" or "supplementary" observations.

WHOLESALE SAMPLING

Unit samples, such as 1-box of apples and 1-flat of strawberries, were obtained, usually on Monday from the distributing center of a large chainstore operation and on alternate weeks from an independent street wholesaler. About a third of each unit was examined at the laboratory, and the rest placed at a specified temperature and for a specified time simulating a warehouse holding period before final examination. Losses were gaged by applying a retail cull standard based on probable acceptance or rejection by the customer. Internal defects, therefore, were not discounted unless severe enough to be externally apparent.

An exception to this examination procedure was made in the 1966 season samples of apples, red potatoes, and peaches. Using these products, the effect of the time lapse between wholesale receipt and consumer use was determined in commodity quality. Wholesale

[1] Italicized numbers in parentheses refer to Literature Cited, p. 21.

samples of the designated items were trimmed in the same way as consumer samples to permit direct comparison. Wholesale losses of the 1966 season for those products are not reflected in the loss tables. Except where specifically noted, loss percentages were based upon weight. Observations of peripheral interest, though not directly concerned with market waste, were also noted as auxiliary observations; these are not reflected in the survey loss tables.

RETAIL SAMPLING

Four stores cooperated in the retail loss phase of the study. Two were members of a major Midwest supermarket chain and were supplied by the parent chain distributing center. Another was a member of a small local chain, and another was an independent operation which at the time of the survey was serviced by the street wholesaler. All stores were modern supermarket facilities situated in suburban Chicago. As a rule, each week one store was visited on Thursday and one on Friday, alternating weeks between the two large chainstores and the small chain and independent retail outlets.

Loss was monitored between store opening and the appearance of the night shift. Waste was gathered from the prepackaging operations and from fresh bulk offerings as well as from shelf rotation. All discards were returned to the laboratory where they were examined, categorized, and recorded. A number of procedures, singly or in combination, were employed to identify diseases. They were microscopic observations of diseased tissue, damp chambering of infected specimens to encourage mold development of the infective agent or culturing of the organism for further laboratory study, or both. This verification procedure was applied to all market phases of the study. Unless otherwise noted, all loss percentages were figured on a weight basis. Information of peripheral interest gathered in the retail survey is noted as auxiliary information.

CONSUMER SAMPLING

Consumer samples were obtained from the shelf presentations of the cooperating stores. One sample was obtained in midmorning and one in midafternoon. These were returned to the laboratory and held for a specified time, at a specified temperature, and then given a simulated consumer trim. Losses consisted of everything cut away in excess of normal paring for the particular product. However, strawberries with objectionable defects were discarded. Also discarded were head lettuce affected by slimy soft rot, potatoes with severe greening, and, in general, fruits with rots over 1 inch in diameter. Citrus was discarded for decay regardless of lesion size. Except where specifically noted, all loss percentages were figured on the basis of weight. Auxiliary observations of peripheral interest were also recorded.

COMMODITY SAMPLING

Apples

Pacific Northwest Red Delicious apples were sampled from mid-September through April 1966-69. They arrived packed in fiberboard cartons with fiberboard or plastic cell liners separating the layers of fruit. The fruit was treated with sodium orthophenylphenate (SOPP) as a general fungicide, and diphenylamine (DPA) to minimize common scald. Size 113, occasionally size 100, fancy or extra-fancy grades were utilized for the wholesale tests. One-third of the fruit was graded immediately upon arrival at the laboratory, the remainder after 3 days at 38° F. Auxiliary observations of wholesale samples included tests for firmness, percent soluble solids, pH, and a record of the occurrence of moldy core and water core. The wholesale samples of the 1966-67 season were utilized to compare directly with the corresponding season consumer samples. For this purpose, wholesale samples were given a consumer trim. For the remaining seasons, wholesale losses were determined by a simulated retail cull.

Retail wastes of the 1966-67 season were restricted to bulk fruit consisting of 113 size and larger; thereafter, wastes from smaller fruit

utilized for prepackaging were included. Auxiliary observations at retail include a comparison of fruit size with category loss, and a comparison of shelf vs. fresh packout waste.

Consumer samples consisted of 10 pounds of bulk apples and 5 pounds of fruit packaged in a pulp tray with a stretch overwrap; occasionally, the fruit was prepackaged in a plastic bag. The samples were held 7 days at 38° F before examination. Auxiliary observations of consumer samples note firmness, percent soluble solids, pH, and the relationship of size to defects by category, and the amount of moldy core and of water core encountered.

Lettuce

California head lettuce was surveyed from mid-April to mid-November 1966-68. Because of a broken 1967 season, lettuce was surveyed through the 1969 season. Lettuce was shipped in fiberboard cartons each holding a normal complement of 24 heads, occasionally 18 heads, naked pack. One-third of the sample was examined upon arrival at the laboratory; final examinations were made of the remaining heads after holding the lettuce for 2 days at 38° F. Lettuce heads were given a simulated retail trim by which the wrapper leaves were eliminated, with all defects beyond this point counted as waste. Auxiliary observations of wholesale samples include a record of gray mold on wrapper leaves and a record of the percentage of product weight loss resulting from the simulated retail trimming process.

Retail loss consisted largely of heads discarded because of decay, immaturity, or other serious defects. Auxiliary observations at retail show the loss encountered in lettuce retrim.

Consumer samples were examined through to the heart leaves with objectionable tissue comprising the loss. Exceptions were consumer lettuce heads affected by slimy soft rot, which were discarded. The usual sample consisted of 10 heads that were held for 3 days at 38° F before examination.

Navel Oranges

Navel oranges from California were sampled from December through April each test season. They were shipped in fiberboard cartons. Sizes 88 and 113 fruit were utilized for the wholesale study. The fruit was protected by the application of sodium orthophenylphenate (SOPP) as a general purpose fungicide and by the presence of two sheets of biphenyl-impregnated paper as a fungistat. One-third of the wholesale sample was examined immediately upon return to the laboratory, and the rest after a 3-day holding period at 38° F. Auxiliary observations of the wholesale samples included determining the percent soluble solids and the pH, and noting the effects of orchard freeze, creasing, and thrips' injury.

Retail waste was determined as previously outlined. Auxiliary observations at the retail level included a comparison of fruit size with loss categories and a comparison of shelf (rotation) waste vs. fresh packout loss.

Consumer samples consisted of bulk fruit, only during the 1966-67 season; thereafter, prepackaged fruit was included. Fruit was packaged either in pulp trays with a plastic overwrap or in polybags. Consumer samples were held 7 days at 38° F before examination. Auxiliary observations made of consumer samples included determining the percent soluble solids, the pH, and the effects of orchard freezing.

Peaches

Peaches were sampled from mid-May to November. The bulk of the fruit originated from southern and southwestern producing areas with minor representation from eastern and midwestern sources. Because of a broken season in 1967, the survey of this item was extended through 1969. Peaches were shipped in dual wood-reinforced fiberboard crates. Treatment typically consisted of washing, brushing, and hydrocooling. One-third of the wholesale samples were graded immediately upon arrival at the laboratory, the rest after a 2-day hold at 38° F. Losses at wholesale were normally determined by a simulated retail cull. The 1966 samples, however, were culled using the consumer method of waste determination for direct comparison of losses between the wholesale and consumer levels. Auxiliary observations compiled during the 1969 season consisted of firmness, percent soluble solids, and pH determinations.

Consumer samples consisted largely of bulk fruit, supplemented by samples prepackaged in pulp trays with a stretch overwrap. Consumer fruit samples were held at room temperature until eating ripe. Auxiliary observations of consumer samples consisted of percent soluble solids and pH determinations obtained during the 1969 season.

Valencia Oranges

Valencia oranges from Florida, sampled from February through June each season, were received in either fiberboard cartons or wirebound woodcrates. Size 100, occasionally size 200, fruit was utilized for the wholesale study. The fruit was routinely protected by a postharvest treatment of orthophenylphenol as a general purpose fungicide. One-third of the wholesale sample was examined immediately upon return to the laboratory; the rest after a 3-day hold at 38° F. Auxiliary observations of wholesale samples include notes on the effect of orchard freeze, a record of the creasing encountered, percent soluble solids, and pH determinations.

Consumer samples consisted of bulk fruit, only during the 1967 season, thereafter, prepackaged fruit was included. Normally, prepackaged fruit were polybagged. Fruit was held 7 days at 38° F. before examination. Auxiliary consumer sample observations noted the effects of orchard freeze.

Potatoes

Red River Valley red potatoes were sampled from October through April, and the California long white potatoes were sampled during May and June. Potatoes were shipped in 100-pound burlap bags or as consumer packs of varying weights packaged in a kraft-paper master container. The potatoes were customarily washed and waxed; additionally the red storage potatoes were treated with isopropyl N (3-chlorophenyl) carbamate to inhibit sprouting. One-third of the wholesale sample was examined upon receipt at the laboratory; the remainder after a 5-day holding period at 60° F. Auxiliary observations on red potatoes at the wholesale level include silver scurf, a reddish discoloration of the cortex, and vascular discoloration. Auxiliary observations on long white potatoes include core browning, vascular discoloration, and black spot.

Retail supplies of California grown long white potatoes were normally received prepackaged at all of the cooperating stores; therefore, waste at the retail level was not recorded. For red potatoes, two of the cooperating retail stores prepackaged bulk potatoes in-store and two dealt in source-packed, or locally prepacked consumer offerings.

Prepackaged potatoes were used for consumer testing. In general, 20 pounds of red and 10 pounds of white potatoes constituted a consumer sample. Both varieties were held for 10 days at room temperature before examination. Auxiliary observations were made on red potatoes for sprouting, vascular discoloration, red cortex discoloration, silver scurf, and an undetermined black fleck condition within the tuber. Similar observations on California long white potatoes include a record of core browning and vascular discoloration. A short season plus a seasonal overlap of storage white potatoes restricted samplings; therefore, the findings are offered provisionally.

Strawberries

Both Californian and southern grown strawberries were customarily shipped in 12-pint fiberboard trays or flats. Berry containers were meshed plastic. No treatment was indicated, but California strawberries were routinely precooled before shipment. California strawberries were surveyed from 1966 through 1969 seasons from mid-April through November. Southern grown strawberries were sampled April through mid-May. Wholesale samples of each consisted of one-flat each. One-third of the sample was examined upon receipt at the laboratory, and the rest after a 1-day hold at 38° F. Auxiliary observations of wholesale samples were made of the percent soluble solids and the pH.

Strawberries are customarily repacked at the retail store with culls segregated during the repacking. These culls constituted the retail loss.

Consumer samples normally consisted of six pints of berries. These were held for 1 day at 38° F before examination. Auxiliary observations record the pH and percent soluble solids.

RESULTS AND DISCUSSIONS

Apples, Pacific Northwest Red Delicious

Wholesale losses

Physical injury to Red Delicious apples was the dominant loss factor, comprising over three-fourths of the 2.9-percent total recorded waste (table 1). Mechanical injuries and bruising were mainly responsible along with some stem puncture and the orchard injuries recorded (table 2).

With 0.5 percent waste, nonparasitic disorders were second high. Common scald was the leading defect with internal breakdown and bitter pit following closely. Insect damage, Diphenylamine (DPA) injury, and delayed sunscald completed the nonparasitic losses (table 2).

Blue mold, bull's-eye, and Alternaria rots comprised the low 0.1 percent loss from parasitic disease (tables 1 and 2).

Auxiliary observations disclosed a gradual reduction in firmness from a mean of 16.8 pounds in September samples to 12.1 pounds in February samples with an overall average of 14.4 pounds. The percent soluble solids averaged 12.1 in September, rising to 14.1 percent in the February tests. The average for all samples was 13.2 percent. The September and February pH readings were pH 3.96 and pH 4.03, respectively. The season average was pH 3.98. Apples affected by moldy core registered 10 percent and water core, 6 percent.

A comparison between the 1966-67 wholesale samples (consumer trimmed) and consumer sample losses revealed the wholesale sample waste was higher in parasitic and nonparasitic categories and lower for the physical category. The cumulative loss percentage of the 1966-67 wholesale samples was approximately 1 percent higher.

Retail losses

Retail loss of 2.9 percent was also led by physical injury (table 1). Bruising and mechanical injury to the apples accounted for nearly 90 percent; orchard injury, stem punctures, and hail damage contributed the rest (table 2).

Nonparasitic losses were 0.2 percent. Common scald was the most frequently occurring nonparasitic disorder closely followed by an off-color condition of the fruit, severe in the 1967 and 1968 season. Insect damage, sunscald, bitter pit, and internal breakdown were also recorded (table 2).

A wide variety of pathogens also contributed 0.2 percent waste. Blue mold and bull's-eye rot led together contributing nearly 80 percent; blue mold rot was dominant by a 2:1 ratio. Storage scab, gray mold rot, Alternaria rot, Rhizopus rot, and brown rot followed (table 2).

Auxiliary observations of the relationship between size and defects revealed larger sized fruit loss to be greater for nonparasitic and physical injury categories by factors of 1.6 and 3.5 times; parasitic disease loss was approximately equal. Shelf waste was greater than fresh packout by factors of 1.1, 1.9, and 1.4 times for parasitic, nonparasitic, and physical injury categories.

Consumer losses

Physical injuries led consumer waste of 2.4 percent for the study with 1.2 percent mostly bruising; mechanical injury, orchard injury, and a trace of stem puncture damage comprised

TABLE 1.—*Market losses of Red Delicious apples, in the Chicago area, 1966-69*

Market channel and year	Nature of market losses				Total sampled
	Parasitic	Non-parasitic	Physical	Total	
	Percent	*Percent*	*Percent*	*Percent*	*Pounds*
Wholesale:					
1966-67[1]	0.2	2.0	0.5	2.7	1,049
1967-68	.2	.5	3.5	4.2	1,257
1968-69	.0	.4	1.1	1.5	1,279
1967-69	.1	.5	2.3	2.9	2,536
Retail:					
1966-67	.3	T[2]	3.2	3.5	7,620
1967-68	.1	.3	3.7	4.1	9,520
1968-69	.2	.2	2.1	2.5	22,687
1966-69	.2	.2	2.5	2.9	39,827
Consumer:					
1966-67	T	.6	1.1	1.7	758
1967-68	.5	2.3	1.2	4.0	566
1968-69	.2	.5	1.2	1.9	790
1966-69	.2	1.0	1.2	2.4	2,114

[1] Not included in wholesale summation.
[2] Trace.

TABLE 2.—*Relationship of market losses, derived by weight, from diseases and defects of Red Delicious apples in the Chicago area, 1966-69*

Specific defects by category	Loss relationships of market levels		
	Wholesale	Retail	Consumer
	Percent	*Percent*	*Percent*
Parasitic:			
Blue mold rot	64	54	42
Bull's eye rot	26	25	39
Alternaria rot	10	4	0
Storage scab	0	10	0
Rhizopus rot	0	2	10
Gray mold rot	0	5	0
Brown rot	0	[1] T	0
Category relationship [2]	**4**	**5**	**9**
Nonparasitic:			
Internal breakdown	22	9	96
Common scald	24	33	0
Bitter pit	20	10	2
Sunscald	10	10	0
Off-color	0	24	0
Insect damage	13	14	2
Diphenylamine injury	11	0	0
Category relationship	**18**	**7**	**42**
Physical:			
Bruising	38	64	96
Mechanical injury	43	23	3
Orchard injury	9	7	1
Stem puncture	10	6	[1] T
Hail damage	0	[1] T	0
Category relationship	**78**	**88**	**49**

[1] Trace.

[2] Ratio of parasitic to nonparasitic to physical losses for each designated marketing level.

the rest (tables 1 and 2).

Apple waste from nonparasitic sources was 1 percent, dominated by internal breakdown with bitter pit and insect damage contributing. Common scald, though present in 0.9 percent of the samples, by count, was not discounted at the consumer level.

Parasitic diseases accounted for 0.2 percent of the total waste. Blue mold rot, bull's-eye rot, and Rhizopus rot were responsible.

Auxiliary observations of consumer samples revealed that the large fruit loss factor over smaller sizes was 1.2 and 1.6 times, for the nonparasitic and physical damage categories; smaller size fruit loss from parasitic disease was greater by a factor of 2.3 times on a count basis. The averages of fruit firmness for October, December, and February were 16.4, 13.4, and 12 pounds, respectively; the 1966-69 season average was 13.6 pounds. Similarly, the percent soluble solids were 12.4, 13.1, and 14.2, with a season average of 13.3; and acidity readings were pH 3.96, pH 3.97, and pH 4.03, with a season average of pH 3.98. Moldy core was noted in 3.1 and 2.9 percent of large and small fruit and water core was present in 4.2 and 2.6 percent.

Discussion

The Northwest apple industry had well-packaged and attractive fruit of excellent quality throughout most of the long season. Physical injury represented the major loss category at all marketing levels. The bruising encountered at wholesale apparently was acquired before storage to judge from the dry, pithy nature of the underlying tissue that was often much more extensive than outward appearances would indicate. Although many sources may contribute to bruising, all the steps in the harvesting and handling operations leading to storage should be reviewed (*12, 17*).

Retail produce managers can minimize physical injury by promoting the concept of gentle handling by employees, by making every effort to reduce fruit to fruit contact in displays, and by eliminating excessive inventory on the floor. Scald and internal breakdown are greatly accelerated by exposure to room temperature. This is especially important toward the end of the season when fruit is becoming overmature. At this time, also, bruising becomes a major problem because of rapid softening of end-of-storage fruit. Tray wrap rather than bagging should be utilized for prepacking.

Nonparasitic problems were generally low, especially at wholesale and retail market channels where the grading method precluded hidden damage. This category showed a sharp rise at the consumer level where internal defects such as breakdown become a consumer fact of life. Common scald was encountered at all levels in small, but persistent, amounts. Since scald may develop rapidly upon removal from cold storage conditions, the appearance of this defect at wholesale indicates a more serious scald problem at the retail and consumer levels. Fortunately, scald is normally superficial and, beyond presenting a poor appearance, does not affect the eating quality of the fruit. Therefore, it was not counted a consumer loss.

Parasitic disease loss was small throughout, with blue mold rot and bull's-eye rot causing most of the loss at each marketing level. Small amounts of decay first appeared in November on wholesale samples, in December on retail samples, and in January on consumer samples, displaying a general increase as the season progressed.

Auxiliary readings disclosed that percent soluble solids and pH readings at both wholesale and consumer levels underwent a gradual rise as the season advanced while fruit firmness gradually declined. Fruit firmness during the 1967-68 season averaged 3 pounds less than for the 1968-69 season a condition that may relate to the higher percentage of physical damage in 1967-68. The pH records of the wholesale and consumer samples proved to be identical in both seasons, but firmness was slightly higher and percent soluble solids were slightly lower for the wholesale fruit. The results between large and smaller sized apples in category losses of the retail and consumer samples showed the larger sizes leading in nonparasitic and physical damage categories, while the parasitic category caused more waste of smaller apples.

The first season results of wholesale and consumer loss were compared with both receiving similar trimming treatment. The findings indicate that condition of the fruit out of storage may be more important to ultimate consumer satisfaction than the effects of added holding time.

Lettuce, California Head

Wholesale losses

Physical injury, caused by crushing and bruising, accounted for 3.6 percent of the total 5.7 percent waste recorded at the wholesale level (table 3).

Nonparasitic disorders (1.6 percent) followed, with russet spot, pink rib, and tipburn accounting for over 90 percent of the category loss. Rib discoloration, insect damage, and a trace of brown stain were also recorded (table 4).

Auxiliary observations revealed gray mold present on 13 percent of the wrapper leaves on a head count basis. Although not a direct loss at wholesale, this infection represented a potential loss threat to both retail and consumer levels.

TABLE 3.—*Market losses of California head lettuce, in the Chicago area, 1966-69*

Market channel and year	Nature of market losses				Total sampled
	Parasitic	Non-parasitic	Physical	Total	
	Percent	*Percent*	*Percent*	*Percent*	*Pounds*
Wholesale:					
1966	[1]T	3.0	2.0	5.1	595
1967	1.5	2.5	1.0	5.0	543
1968	.1	2.5	5.8	6.4	786
1969	.7	.9	4.4	6.0	624
1966-69	.5	1.6	3.6	5.7	2,548
Retail:					
1966	.4	.6	.7	1.7	13,638
1967	1.1	.7	.4	2.2	3,633
1968	.8	.1	.1	1.0	15,854
1969	.7	.6	1.7	3.0	8,684
1966-69	.7	.4	.6	1.7	41,809
Consumer:					
1966	1.1	4.4	8.3	13.8	575
1967	1.1	3.7	6.5	10.3	322
1968	.4	3.7	12.9	17.0	543
1969	.7	3.7	8.7	13.1	460
1966-69	.6	3.9	9.4	13.9	1,900

[1] Trace.

Reduction of the wrapper leaves, to the degree comparable to retail trim practice, resulted in an average weight reduction per head of 26 percent.

Retail losses

Losses from parasitic disease amounted to 0.7 percent of the 1.7 percent total retail waste. Bacterial soft rot in lettuce was the principal offender with gray mold rot being the only other parasitic factor of consequence. During the 1969 season, however, a slight amount of downy mildew and stemphylium was noted, with stemphylium following sunscald injury.

The physical injury category loss was 0.6 percent. This category included heads that were crushed, bruised, or otherwise mechanically damaged. Many of those heads were underdeveloped, extremely soft, and highly susceptible to crushing (tables 3 and 4).

Nonparasitic defects accounted for 0.4 percent loss at retail level. Russet spot dominated, with pink rib, rib discoloration, insect damage, tipburn, and sunscald following. Traces of brown stain and freezing were also present.

Other observations were made during the retrimming of shelf lettuce. From 525 pounds

reworked by the investigator, parasitic (bacterial soft rot), nonparasitic (russet spot), and physical injury (including shelf wilting) categories contributed losses of 0.8, 10.9, and 3.7 percent on a weight basis. Practical store loss, however, is more closely related to loss figured by count since retrimmed heads are usually offered on a 2-for-1 resale basis. Accepting as a base the original inventory by count, from which the retrimmed heads issued, the loss was 12 percent for the store. This does not include the expense of labor or material involved.

Consumer losses

The consumer loss of 13.9 percent was dominated throughout the study by the physical damage category. The 9.4 percent physical damage loss included leaf wilting as well as actual physical injury as it is often associated on the cover leaves.

Nonparasitic disorders accounted for a 3.9 percent loss. As with the wholesale and retail channels, russet spot led throughout. Pink rib, tipburn, rib discoloration, insect damage, and brown stain contributed the balance.

Parasitic diseases accounted for 0.6 percent loss; largely bacterial (slimy) soft rot, with gray mold rot, and a trace of anthracnose also recorded.

TABLE 4.—*Relationship of market losses, derived by weight, from diseases and defects of California head lettuce in the Chicago area, 1966-69*

Specific defects by category	Loss relationships of market levels		
	Wholesale	Retail	Consumer
	Percent	*Percent*	*Percent*
Parasitic:			
Bacterial soft rot	91	67	92
Gray mold rot	7	33	8
Downy mildew	2	T	0
Anthracnose	0	0	[1] T
Stemphylium	0	T	0
Category relationship [2]	9	39	5
Nonparasitic:			
Russet spot	63	78	77
Pink rib	19	8	12
Tipburn	12	3	4
Brown stain	T	T	1
Rib discoloration	3	5	4
Freezing	0	T	0
Sunscald	0	1	0
Insect damage	3	5	2
Category relationship	29	21	27
Physical:			
Crushed and bruised	100	100	100
Category relationship	62	37	68

[1] Trace.

[2] Ratio of parasitic to nonparasitic to physical losses for each designated marketing level.

Discussion

The dominant category of loss of lettuce at the wholesale and consumer level was physical injury, while parasitic disease was highest at retail. The latter reflects the policy of total discard when dealing with severe quality problems. Physical injury is encouraged by the size and structure of the lettuce carton, by the tendency toward heavier loads in-transit, and by high stacking at warehouse and retail facilities. Immature, soft heads contribute to this injury loss pattern. Those heads should be eliminated at the time of field packing. Such action, plus the adoption of a stronger container or a reduction of load weight, or both, would be beneficial.

Nonparasitic disorders of lettuce were dominated by russet spot at all marketing channels throughout the study. Fifteen percent increase in russet spot was registered for the study between wholesale and consumer levels. Pink rib was a consistent second. The remaining nonparasitic defects exhibited ratings split among the marketing channels with their relative importance being dictated by the emphasis accorded at the particular market level. Tipburn, which commonly occurs within the head, becomes more of a factor at the consumer level. Many physiological defects of lettuce are poorly understood. With increasing knowledge some relief from these losses may be anticipated (*2, 7, 14, 23*).

Bacterial soft rot was the greatest cause of lettuce waste because of decay-inducing organisms. This is a weak parasite attacking tissue weakened or killed by parasitic or nonparasitic causes, and crushed or bruised tissue. The prevention of physical injury in a commodity as tender as lettuce is difficult, but care in handling, prompt postharvest heat reduction, and maintenance of recommended temperatures throughout the marketing period remain the best methods to reduce parasitic loss (*14*).

The simulated retail trim conducted with wholesale samples indicates a high product loss from this operation. Although lettuce may be trimmed too heavily at retail, the trade feels that the consumer prefers a well-trimmed head. The prevailing use of automatic cutters and the pressure of keeping up with consumer demand for this high-volume salad item together make selective trimming difficult at retail. Wrapper leaves are heavier because of a greater leaf area and a heavier midrib construction; consequently their removal results in a disproportionate loss percentage.

Oranges, California Navel

Wholesale losses

Parasitic disease dominated the 2.0 percent loss of navel oranges registered at the wholesale level. Green mold rot, blue mold rot, and Alternaria rot accounted for nearly 90 percent of this category and the parasitic category accounted for 74 percent of the total losses (tables 5 and 6).

Nonparasitic losses, largely because of rind breakdown, was second with 0.3 percent.

Physical injury comprised of mechanical injury and bruising registered 0.2 percent of the total waste.

Auxiliary observations indicated the percent soluble solids were 10.4, 13.1, and 12.3 percent for December, February, and April, respectively. The season average was 12.1 percent. Similarly, pH readings were pH 3.41, pH 3.46, and pH 3.68, with an average of pH 3.53. During the 1966-68 seasons a drying of the pulp extending in from the stem-end was observed. It was attributed to orchard freezing. An average of 0.4 percent slight to moderate (up to three-fourth inches in depth) in severity was recorded. Creasing averaged 0.8 and 2.5 percent for 1968 and 1969. Thrips injury monitored during the 1969 season, was found on 4.9 percent of the samples. Auxiliary disorder percentages were based on count.

Retail losses

Loss from parasitic disease dominated the 1.6 percent retail waste, contributing 75 percent of the total retail waste of navel oranges. Green and blue mold rots accounted for over 90 percent. Brown rot, Alternaria rot, and anthracnose comprised the rest of the measurable waste. Trace amounts of stem-end rot, sour rot, and gray mold rot were also observed.

TABLE 5. —*Market losses of navel oranges, in the Chicago area, 1966-69*

Market channel and year	Nature of market losses				Total sampled
	Parasitic	Non-parasitic	Physical	Total	
	Percent	*Percent*	*Percent*	*Percent*	*Pounds*
Wholesale:					
1966-67	2.7	0	0.3	3.0	567
1967-68	.8	.5	.2	1.5	759
1968-69	1.2	.4	4.3	1.9	744
1966-69	1.5	.3	.2	2.0	2,070
Retail:					
1966-67	.9	.2	.1	1.2	21,472
1967-68	.9	.4	.1	1.4	9,125
1968-69	1.4	.1	.3	1.8	34,350
1966-69	1.2	.2	.2	1.6	64,947
Consumer:					
1966-67	2.5	0	0	2.5	847
1967-68	2.3	0	.1	2.4	446
1968-69	1.2	.2	.1	1.5	597
1966-69	2.1	.1	T	2.2	1,890

T Trace.

Physical damage amounted to 0.2 percent and was principally due to soilage of bagged fruit caused by heavy coating of green mold spores deposited by adjacent rotted fruit. Crushing, bruising, and slight loss from scarring contributed the rest.

Loss because of nonparasitic causes was 0.2 percent. Rind breakdown accounted for 68 percent of this category followed by a puffy condition (prevalent during the 1967-68 season) on large fruit, creasing, and a small amount of pitting.

Auxiliary observations revealed no appreciable difference between fruit size and category loss. The larger sizes (113 and over) had slightly more physical and physiological and slightly less parasitic loss than did smaller sized oranges based only on fresh packout culls. Shelf waste was greater than fresh packout cull by factors of 1.35, 1.44, and 4.68 times for parasitic, nonparasitic, and physical categories. The fresh packout inventory, however, was seven times larger.

Consumer losses

The parasitic disease category continued to dominate the navel orange, providing 95 per-

cent of the 2.2 percent consumer loss. Again, this was primarily due to the green and blue mold rots with a ratio of 2:1. Alternaria rot, brown rot, and anthracnose were responsible for the rest.

Nonparasitic loss was 0.1 percent, entirely from rind breakdown. This defect scored at the consumer level only when it was so severe as to impair the flavor of the fruit.

Only a trace of physical injury was recorded, and that was from mechanical injury (tables 5 and 6).

Auxiliary consumer observations recorded the same drying at the stem-end noted in wholesale samples during 1966-68. The average percentage was 5.8 with 62 percent of this judged to be slight (up to one-fourth inch in depth), 14 percent moderate, and 24 percent severe (over three-fourth inch in depth). Percent soluble solids and pH readings were taken during 1968-69 season. December, February, and April readings averaged 10.5, 12.1, and 12.7 percent soluble solids; and pH 3.34, pH 3.79, and pH 3.86, respectively. The average of all samples for the season was 12.4 percent soluble solids and pH 3.65.

TABLE 6.—*Relationship of market losses, derived by weight, from diseases and defects of California navel oranges in the Chicago area, 1966-69*

Specific defects by category	Loss relationships of market levels		
	Wholesale	Retail	Consumer
	Percent	*Percent*	*Percent*
Parasitic:			
Green mold rot	62	75	53
Blue mold rot	17	17	27
Septoria rind spot	3	0	0
Alternaria rot	10	2	13
Anthracnose	4	1	2
Brown rot	3	4	5
Stem-end rot	1	[1] T	0
Sour rot	0	[1] T	0
Gray mold rot	0	[1] T	0
Category relationship [2]	71	75	95
Nonparasitic:			
Rind breakdown	84	68	100
Creasing	0	5	0
Puffy	0	26	0
Pitting	0	1	0
Insect damage	16	0	0
Category relationship	17	12	3
Physical:			
Bruising	47	32	0
Mechanical injury	53	32	100
Scarring	0	1	0
Soilage	0	35	0
Category relationship	9	13	2

[1] Trace.

[2] Ratio of parasitic to nonparasitic to physical losses for each designated marketing level.

Discussion

Oranges were the only product studied having decay as the prime source of loss at every marketing channel. This points up the need for postharvest protection against pathogenic organisms, green and blue mold rots in particular. Postharvest chemical washes are employed to reduce loss from decay. Hot water has been used alone as well as used to increase the effectiveness of chemical treatment. Prophylactic measures, however, must be reinforced by careful handling to minimize injury to the fruit and supplemented by proper refrigeration throughout the marketing process (*20, 21, 22*).

Nonparasitic losses were relatively low and were largely confined to rind breakdown. The record suggests satisfactory handling practices and a relatively rapid movement through the channels of trade. Emphasis on the necessity for continued rotation of retail shelf offerings would reduce the soilage problem encountered. Insect damage was due to chewing insects, presumably katydid or grasshopper with consequent unsightly scarring of the fruit surface.

Physical losses also were low, from good packaging and the natural protection afforded by a relatively thick resilient rind. The absence of appreciable losses in the nonparasitic and physical injury categories made possible a commendably low cumulative loss total for all marketing channels.

The percent soluble solids and the pH readings showed a general increase with the advance of the season at both the wholesale and the consumer levels.

Oranges, Florida Valencia

Wholesale losses

The parasitic disease category dominated the total 1.4 percent of the waste observed at the wholesale level (table 7). Green mold was the principal cause of decay. Anthracnose, Alter-

naria rot, stem-end rot, and Fusarium contributed the rest (tables 7 and 8).

Nonparasitic disorders amounted to 0.4 percent. Rind breakdown and a puffy condition of large sized fruit were the principal causes. Rind breakdown was a factor throughout the study, the puffy fruit condition during the 1968 season.

Loss from physical injury in crushed and bruised fruit was negligible, contributing 0.1 percent of total losses.

Auxiliary observations were made of a stem-end drying condition characteristic of orchard freeze. The defect was first encountered in March of 1968 and again in 1969, and continued through to the end of each season. The average for both seasons was 30 percent. Creased fruit was present in 0.5 percent of the 1969 samples. The percent soluble solids, determined in February, April, and June were 11.8, 12.5, and 13.7 percent. Similar pH determinations revealed pH 3.68, pH 3.48, and pH 3.81. The average of all readings during the seasons was 12.4 percent soluble solids and pH 3.63.

Retail losses

Loss from parasitic diseases was the primary cause of the 0.8 percent retail loss. Green and blue mold rots at a 2:1 ratio contributed 84 percent. Anthracnose, stem-end rot, and sour rot contributed the remaining measurable loss. A trace of brown rot, Fusarium rot, and Alternaria rot were encountered (tables 7 and 8).

Nonparasitic losses of Valencia oranges that contributed 0.1 percent consisted of rind breakdown and a trace of sunscald.

Physical injuries caused by crushing amounted to a trace.

Consumer losses

The consumer loss of 3.7 percent was dominated by parasitic diseases. Green and blue mold rots in a 2:1 ratio contributed 76 percent. Stem-end rot (largely Phomopsis), anthracnose, Alternaria rot, and small amounts of sour rot and Pestalotia rot followed.

Mechanical injury and severe bruising caused 0.2 percent loss. Both conditions were aggravated by creasing and a puffy condition.

Rind breakdown was the sole contributor to the nonparasitic disorder category with 0.2

TABLE 7.—*Market losses of Valencia oranges, in the Chicago area, 1967-69*

Market channel and year	Nature of market losses				Total sampled
	Parasitic	Non-parasitic	Physical	Total	
	Percent	*Percent*	*Percent*	*Percent*	*Pounds*
Wholesale:					
1967	0.6	0.1	0.2	0.9	706
1968	1.2	.4	0	1.6	749
1969	1.0	.6	.1	1.7	582
1967-69	.9	.4	.1	1.4	2,037
Retail:					
1967	1.9	.1	.1	2.1	2,418
1968	.6	.1	[1]T	.7	7,284
1969	.4	.1	.1	.6	6,482
1967-69	.7	.1	[1] T	.8	16,184
Consumer:					
1967	3.6	.2	.1	3.9	587
1968	2.9	.3	.5	3.7	488
1969	3.2	0	0	3.2	183
1967-69	3.3	.2	.2	3.7	1,258

[1] Trace.

TABLE 8.—*Relationship of market losses, derived by weight, from diseases and defects of Valencia oranges in the Chicago area, 1966-69*

Specific defects by category	Loss relationships of market levels		
	Wholesale	Retail	Consumer
	Percent	*Percent*	*Percent*
Parasitic:			
Green mold rot	65	56	53
Blue mold rot	0	28	23
Stem-end rot	8	5	11
Sour rot	0	5	1
Anthracnose	13	6	8
Brown rot	0	[1] T	0
Fusarium rot	3	[1] T	0
Alternaria rot	11	[1] T	3
Pestalotia rot	0	0	1
Category relationship [2]	66	86	88
Nonparasitic:			
Rind breakdown	63	96	100
Sunscald	0	4	0
Puffy	32	0	0
Insect damage	5	0	0
Category relationship	28	9	5
Physical:			
Bruising	0	0	72
Mechanical injury ...	100	100	28
Category relationship	6	5	7

[1] Trace.

[2] Ratio of parasitic to nonparasitic to physical losses for each designated marketing level.

percent. The defect was scored at the consumer level only if so severe as to induce an off-flavor condition of the fruit.

Auxiliary observations revealed stem-end drying due to orchard freeze averaged 24 percent of the combined 1968-69 season samples, most of which was slight.

Discussion

Parasitic disease losses dominated at all marketing channels, accounting for 66 to 88 percent of the waste recorded during the test seasons. Consumer losses from decay were 3.5 times greater than wholesale losses, and 4.5 times that of retail.

Loss from nonparasitic disorders and physical injury were relatively low. Nonparasitic disorders were comprised largely of rind breakdown, and physical injury was crushing and bruising. Oranges represented a striking exception to the dominance of physical injury as a factor of market loss.

Auxiliary observations showed percent soluble solids and pH readings at the wholesale and consumer levels increasing with the advance of the season. Orchard freeze injury was not entered as a direct market loss since most of the fruit was affected only slightly, and an accurate assessment of consumer loss of juice oranges presented difficulties.

Peaches, Southern

Wholesale losses

Wholesale samples of peaches from the 1966 season received a consumer trim that compared directly with the corresponding consumer loss record. This was done to gage the effect of waste on soft fruits and the time span between the marketing levels. A direct comparison reveals the effect of time and shelf-exposure environment. No parasitic waste was recorded on wholesale samples; by contrast, this category was 41 percent of the consumer waste. Likewise, there were no nonparasitic defects in the wholesale samples; the same factors of time and shelf exposure encouraged the appearance of internal breakdown in consumer samples. Losses from physical injury in the first year wholesale samples were 1 percent; this also represented the total loss. Corresponding 1966 consumer loss from physical damage was 2.8 percent with a total loss of 5.9 percent (table 9).

For the remaining seasons of the survey, wholesale samples of peaches were subjected to a simulated retail evaluation. Physical injury led the 12.3 percent total with 9.4 percent. It consisted of bruising, mechanical injury, and scarring (table 10). With bruising, an extremely soft bruise was affecting green-ripes and turning fruit in some arrival shipments. Bruising was found in about 9 and 17 percent, by count, of the 1968 and 1969 samples. Although these fruits were incorporated in the general bruise category, subsequent investigation (*1*) revealed that the sour rot organism was involved. Hard-ripe peach fruits exhibiting bruise areas of extremely soft-flesh texture should be suspected of harboring sour rot.

The parasitic disease category, of which brown rot, sour rot, gray mold rot, and scab were responsible, accounted for 2.4 percent waste.

Nonparasitic disorders in peaches accounted for 0.5 percent loss. These were rejects related to insect damage and sunscald.

Auxiliary observations revealed fruit firmness, measured at arrival examination,

TABLE 9.—*Market losses of peaches, in the Chicago area, 1966-69*

Market channel and year	Nature of market loss				Total sampled
	Parasitic	Non-parasitic	Physical	Total	
	Percent	*Percent*	*Percent*	*Percent*	*Pounds*
Wholesale:					
1966[1]	0	0	1.0	1.0	295
1967	0	0	5.1	5.1	80
1968	3.5	.5	4.6	18.6	446
1969	1.4	.5	4.6	6.5	564
1967-69	2.4	.5	9.4	12.3	1,090
Retail:					
1966	1.0	0	5.7	6.7	3,456
1967	2.1	[2]T	8.9	11.0	2,141
1968	1.2	.1	3.8	5.7	21,555
1969	1.1	.1	4.7	5.9	11,535
1966-69	1.2	.1	4.5	5.8	38,687
Consumer:					
1966	2.4	.7	2.8	5.9	220
1967	9.1	0	3.9	13.0	65
1968	11.8	.4	4.9	17.1	240
1969	6.0	.2	2.5	8.7	276
1966-69	7.0	.4	3.4	10.8	801

[1] Not included in wholesale summation.
[2] Trace.

TABLE 10.—*Relationship of market losses, derived by weight, from diseases and defects of peaches in the Chicago area, 1966-69*

Specific defects by category	Loss relationships of market levels		
	Wholesale	Retail	Consumer
	Percent	*Percent*	*Percent*
Parasitic:			
Brown rot	62	84	87
Gray mold rot	8	11	0
Sour rot	28	4	6
Scab	2	0	0
Rhizopus rot	0	[1] T	6
Alternaria rot	0	[1] T	0
Bacterial spot	0	[1] T	0
Penicillium rot	0	[1] T	0
Anthracnose	0	0	1
Pestalotia	0	0	T
Phomopsis	0	0	T
Category relationship [2]	19	20	65
Nonparasitic:			
Internal breakdown	0	0	61
Sunscald	4	[1] T	0
Freeze damage	0	9	0
Growth crack	0	9	0
Malformed	0	[1] T	0
Shriveling	0	9	0
Insect damage	96	73	39
Category relationship	1	2	3
Physical:			
Mechanical injury	38	6	10
Scarring	3	[1] T	0
Bruising	59	94	90
Category relationship	77	78	32

[1] Trace.

[2] Ratio of parasitic to nonparasitic to physical losses for each designated marketing level.

ranged from slightly over 5 to 17.1 pounds, with an average 11.8 pounds. After a 3-day hold at 38° F, firmness ranged from 4.1 to 15.5 pounds and averaged 11.2 pounds. Percent soluble solids ranged from slightly over 9 to slightly under 13 at initial examinations, with an average 10.9. At the time of final examinations, these readings ranged from 9 to 12.5 with an average 10.7 percent. Acidity readings ranged from pH 3.46 to pH 3.77, with an average pH 3.65 for initial examinations and from pH 3.51 to pH 3.86 with an average of pH 3.57 for final examinations.

Retail losses

The retail waste of 5.8 percent was led by physical damage, largely bruising, with some mechanical injury and a trace of scarring.

Brown rot dominated the 1.2 percent parasitic disease waste. Gray mold rot, sour rot, traces of Rhizopus, Alternaria rot, bacterial spot, and Penicillium rot were also encountered (table 10).

Nonparasitic disorders account for 0.1 percent of total waste. These disorders were insect damage, shriveling, growth cracks, and freeze damage. Traces of sunscald and malformed fruit were also present.

Consumer losses

The parasitic disease category led consumer losses with 65 percent of the total loss, with brown rot largely responsible.

Waste from physical injuries was 3.4 percent due mostly to bruising.

Nonparasitic disorders accounted for 0.4 percent caused by internal breakdown and insect damage.

Auxiliary observations of the 1969 season consumer samples showed a fruit firmness from pressure tests of from 4 to 5 pounds, averaging 4.5 pounds at the time of examination. Soluble solids rated from slightly under 10 percent initially to 11.3 toward the end of the season, with an average 10.9 percent. Acidity ranged from pH 3.57 initially to 3.71, averaging pH 3.67 for the season.

Discussion

Bruising and mechanical damage were the primary losses at both the wholesale and retail levels where the relative state of immaturity discouraged decay organisms. Categories were reversed at the consumer level as the ripening peaches became increasingly susceptible, both physiologically and physically, to parasitic attack.

Loss from decay is of particular concern to the consumer who has the fruit when fully ripe. To minimize loss from decay, the consumer should purchase fruits for immediate use that are eating ripe and free of injury and spots which indicate initial decay. "Buy less, more often" should be the rule for soft fruits. Care should be exercised to avoid injuring the fruit. Throughout the study, higher decay percentages reflected higher physical damage loss.

The parasitic, nonparasitic, and physical category relationships between wholesale and retail losses were quite similar, differing by only 1 to 2 percent. Retail shelf losses were greater

than fresh packout waste for the parasitic and nonparasitic categories by factors of 1.87 and 2.67 times. Corresponding physical injury losses were virtually alike. Fresh packout inventory, however, was greater than shelf inventory by a 5:1 ratio.

Parasitic disease and physical injury of peaches at the consumer level were inherited from the wholesale and retail time factor, plus a postpurchase period often required to complete ripening of the fruit. Aided by the same factors that promoted decay, internal breakdown became the dominant factor in consumer nonparasitic losses. Insect damage usually resulted in a deep dimple, presumably caused by sucking insects attacking the young fruit.

Potatoes, Red River Valley Red

Wholesale losses

Physical injuries accounted for 2.9 percent of the red potato loss. Parasitic diseases caused 1.3 percent loss, largely from Fusarium dry rot. Nonparasitic disorders, dominated by cracking and greening contributed 0.7 percent (tables 11 and 12).

TABLE 11.—*Market losses of Red River Valley red potatoes, in the Chicago area, 1966-69*

Market channel and year	Nature of market loss				Total sampled
	Parasitic	Non-parasitic	Physical	Total	
	Percent	*Percent*	*Percent*	*Percent*	*Pounds*
Wholesale:					
1966-67 [1]	0.3	1.9	0.7	2.9	1,821
1967-68	1.7	.4	2.8	4.9	2,437
1968-69	.9	1.0	3.1	5.0	2,478
1967-69	1.3	.7	2.9	4.9	4,915
Retail:					
1966-67	[2] T	.1	.4	.5	17,400
1967-68	.2	.1	.7	.5	9,400
1968-69	.1	.3	1.1	1.5	17,500
1966-69	.1	.2	.7	1.0	44,300
Consumer:					
1966-67	.5	1.9	1.5	3.9	1,398
1967-68	1.5	.6	1.0	3.1	1,030
1968-69	.7	1.0	2.2	3.9	911
1966-69	.9	1.3	1.5	3.7	3,339

[1] Not included in wholesale summation.
[2] Trace.

TABLE 12.—*Relationship of market losses, derived by weight, from diseases and defects of Red River Valley red potatoes in the Chicago area, 1966-69*

Specific defects by category	Loss relationships of market levels		
	Wholesale	Retail	Consumer
	Percent	*Percent*	*Percent*
Parasitic:			
Fusarium dry rot	73	57	85
Bacterial soft rot	20	41	11
Bacterial ring rot	1	0	4
Scab	4	2	[1] T
Penicillium	0	0	[1] T
Rhizoctonia	[1] T	0	[1] T
Alternaria tuber rot	1	0	0
Silver scurf	1	0	0
Late blight	[1] T	0	0
Category relationship [2]	27	10	24
Nonparasitic:			
Internal black spot	0	0	18
Greening	39	47	68
Hollow heart	0	0	6
Freeze damage	2	42	1
Cracking	42	11	6
Scald	2	0	0
Insect damage	15	0	1
Category relationship	11	16	34
Physical:			
Mechanical injury	96	100	100
Bruising	4	0	0
Category relationship	59	74	42

[1] Trace.
[2] Ratio of parasitic to nonparasitic to physical losses for each designated marketing level.

A direct comparison of the loss of 1966-67 season wholesale samples (given a simulated consumer trim) was made with corresponding consumer losses. It revealed wholesale losses less or equal in all categories with cumulative total of 1 percent less than the 3.9 percent consumer loss of the 1966-67 season.

A number of auxiliary observations were made from the wholesale samples of red potatoes of the 1967-68 and 1968-69 seasons. Silver scurf became intrusive during the latter months of storage, and it was tabulated during February and March. Wholesale samples in 1968 revealed silver scurf to be slight in 9.2 percent of the samples; moderate (one-fourth to one-half of the surface affected) in 3 percent; and severe in 1.4 percent. In 1969, it was present in 18.7, 4.1, and 0.6 percent of the samples.

Vascular discoloration was tabulated in

March 1968 when it showed 4.3, 1.4, and 3.3 percent—slight, moderate (one-fourth to one-half of the potato length), and severe. This defect was monitored again in November through March 1969; discoloration was present in 8.1 and 0.5 percent of the samples, slight and moderate, respectively. Sprouting was tabulated in March 1968. It was present in 2.7 and 0.7 percent, slight and moderate (5-10 mm sprouts). A similar check conducted during February and March 1969 recorded 9 percent slight sprouting. A red discoloration of the flesh of the potato from possible genetic origin was found present in 2.7 percent of the 1968-69 samples based on a cutting of 4 percent of the samples.

Retail losses

Physical damage, largely of field origin, caused 0.7 percent of the 1 percent retail waste in red potatoes. Nonparasitic disorders, mostly freeze damage and greening, accounted for 0.2 percent. Parasitic diseases comprised largely of Fusarium and bacterial soft rot caused 0.1 percent waste.

Consumer losses

Consumer losses were 3.7 percent. Cumulative loss for each season was relatively uniform although category variations were apparent from year to year. Nonparasitic disorders were highest in 1966-67; parasitic disease in 1967-68, and physical injuries in 1968-69. Mechanical injuries apparently incurred largely during harvesting were the principal physical damage factor, and greening was the principal nonparasitic defect. Fusarium was the dominant parasitic disease.

Additional observations made during the 1968-69 season revealed vascular discoloration present throughout the season, averaging 9.6 percent, of which 80 percent extended less than one-fourth of the length of the tuber end and were rated slight.

Sprouting was first encountered in December samples, and it was present thereafter in amounts ranging from 12 to 55 percent. The season average was 21.9 percent, of this 55 percent was slight, 34 percent moderate (sprouts 5-10 mm long), and 11 percent severe.

Silver scurf became intrusive in January. Percentages ranged from 9 to 55 percent for the remainder of the season and averaged 17.9 percent. Of this, 64 percent were slight, 21 percent moderate (one-fourth to one-half of the surface affected), and 15 percent severe.

The red discoloration of the tuber cortex previously noted at wholesale was intermittent. It was encountered in November consumer samples in amounts of less than 0.5 percent. January, February, and March had 1.4, 1.2, and 0.9 percent, with an average of 0.9 percent for the entire season. A disorder, unfamiliar to the investigators, consisting of small, widely scattered black flecks occurring throughout the tuber, either within or without the vascular ring, was also observed. This disorder was scattered in occurrence, being noted in October at 1.7 percent, in March when 13.5 percent of the consumer samples were affected, and again in April when this defect was registered in 27.9 percent of the samples.

Discussion

Physical injury, causing the most waste to red potatoes at all levels of marketing, resulted mainly from injuries incurred during harvest. This suggests that potatoes should be constantly monitored during harvesting to insure proper blade depth and to assess the effect of chain speed. Tighter grading on the harvester, at the point of storage, at storage packout, and with retail prepack or bulk potato retail display, or both, should be stressed.

Parasitic loss was generally low. Fusarium dominated throughout the survey followed by bacterial soft rot. Both could be decreased by a reduction of physical injury since each requires wounds for entry. Tubers should be cooled slowly after being placed in storage. This practice permits the rapid development of a protective infection barrier through the formation of cell cork to resist invasion by pathogens (*9, 11, 13, 18*).

Greening dominated the physiological category. This is a cumulative factor dependent upon exposure to light. Preharvest rains, not uncommon in the valley, which expose subsurface tubers aggravate this disorder. It may, however, appear at any stage of marketing. The most effective method of preventing greening is to protect the tubers from light (*4*). The time between digging and storing should be as short as possible and covering the loads with a tar-

paulin from field to storage would be beneficial. The tubers can be protected during marketing with heavy burlap bags or heavy kraft paper bags. (*8, 13*).

Cracking, a response of turgid potatoes to sudden atmospheric changes or to mechanical abuse or pressure, or both, was prevalent. Variety, failure to kill the vines far enough in advance of harvesting to permit maturation of the tubers, and rough handling all have been implicated in this disorder (*11, 13*).

Of the auxiliary defects noted on red potatoes, perhaps sprouting and silver scurf represent the most visible, and the most damaging, defects at the retail level. Actually only few sprouts were observed on the bulk of the samples. Considering the length of the storage life of potatoes, sprout inhibitors are effective. Silver scurf became severe toward the end of the storage season. Although it does not affect the eating quality of the tuber, it does, in common with sprouting, create a shriveling problem and can be an unsightly blemish factor. Insect damage was caused largely by wireworm, and it was noted in small but persistent amounts throughout the study.

Potatoes, California Long White

Wholesale losses

The cumulative wholesale loss of 2.5 percent for long white potatoes in the survey was dominated by the physical injury category with 1.7 percent. This was largely due to a fracturing of the potatoes encouraged by the turgid nature of the fresh tubers (table 13).

Nonparasitic losses were 0.5 percent due principally to greening, with a small amount of browning, insect damage, and heat injury also recorded (tables 13 and 14).

The parasitic category registered 0.3 percent loss, mostly bacterial soft rot of which 10 percent was evident as lenticel infection. A small amount of scab and leak was also recorded.

Auxiliary observations of long white potatoes noted the presence and degree of several nonparasitic defects during the 1968 and 1969 seasons which were not discountable at the wholesale level. One was a previously unobserved internal defect designated as core browning, a rusty-brown flecking of the central core. The cause is not determined. The 1968 season had 5.2 and 4.3 percent of this defect during May and June; while the 1969 season registered 6.7 and 3.0 percent over 90 percent that was slight (less than one-half inch in length). All of the 1968 samples and 65 percent of the 1969 samples were cut. Vascular discoloration was monitored

TABLE 13.—*Market losses of California long white potatoes, in the Chicago area, 1967-69*

Market channel and year	Nature of market loss				Total sampled
	Parasitic	Non-parasitic	Physical	Total	
	Percent	*Percent*	*Percent*	*Percent*	*Pounds*
Wholesale:					
1967	0.4	0.4	0.1	0.9	302
1968	.1	.3	2.5	2.9	701
1969	.2	.9	1.7	2.8	694
1967-69	.3	.5	1.7	2.5	1,697
Consumer:					
1967	.8	.0	.0	.8	42
1968	.1	.0	.0	.1	41
1969	.2	2.4	.9	3.5	100
1967-69	.3	1.6	.5	2.4	183

TABLE 14.—*Relationship of market losses, derived by weight, from diseases and defects of California long white potatoes in the Chicago area, 1966-69*

Specific defects by category	Loss relationships of market levels	
	Wholesale	Consumer
Parasitic:	*Percent*	*Percent*
Bacterial soft rot	78	0
Scab	5	0
Leak	17	0
Fusarium dry rot	0	100
Category relationship [2]	10	13
Nonparasitic:		
Black spot	0	38
Greening	65	62
Heat injury	8	0
Browning	19	0
Insect damage	8	[1] T
Category relationship	21	67
Physical:		
Mechanical injury ...	94	100
Bruising	6	[1] T
Category relationship	69	20

[1] Trace.

[2] Ratio of parasitic to nonparasitic to physical losses for each designated marketing level.

throughout the third season; it averaged 1.8 percent, all slight. Black spot, also surveyed the third season, averaged 7.1 percent. The preceding auxiliary observation percentages were based on count.

Consumer losses

Nonparasitic losses made up the bulk of the 2.4 percent total consumer loss for the study with 1.6 percent mostly from greening. Black spot and a trace of insect damage were recorded.

Broken and shattered tubers accounted for most of the 0.5 percent physical damage.

The parasitic category accounted for 0.3 percent waste, comprised entirely of Fusarium dry rot.

Retail losses

The bulk of the California long white potatoes arrived at the stores prepacked. Retail loss was limited to sporadic troubles with individual bags, and it was largely confined to greening. Spot checks suggested that the loss from this source was 5 percent.

Discussion

In general, California long white potatoes presented an excellent appearance being clean, bright, and relatively free of defects.

Mechanical injury was the primary cause of rejects from wholesale samples. These injuries were largely postharvest, principally fracturing resulting from rough handling of fresh turgid potatoes.

The nonparasitic category of long white potato losses dominated by greening was the high waste source at the consumer level. A count survey made during the 1968 season revealed greening evident in 19 percent of the consumer samples. Greening was scored relatively lightly not only because of the questionable amounts of direct loss involved in consumer levels, but also because a 10-day hold constituted a rather stringent test on this item which would normally be inventoried much more closely by the aware consumer. Since greening is caused by exposure to light and tends to be cumulative, the prevention lies in excluding light insofar as possible.

Master containers provide sufficient protection until consumer packages are removed. Normally, this would be done at the retail store. Master containers should be left intact until floor samples are required; these supplies should be kept to a minimum and serviced more often. The consumer should transfer the purchased potatoes to a heavy kraft paper bag to protect them from the greening effect of light. A consumer package affording a high degree of light protection is required for this light-sensitive item, even at the cost of reduced visibility (*4, 13*).

Parasitic loss was low at both marketing stages studied; internal black spot caused more consumer waste than decay.

Strawberries, California and Southern

Wholesale losses

Physical damage of 8.7 percent dominated the strawberry wholesale study loss. Parasitic disease and nonparasitic disorders caused 2.7 and 2.1 percent loss. The former was dominated by gray mold, and the latter by green fruit and a berry injury characteristic of that caused by slugs (tables 15 and 16).

TABLE 15.—*Market losses of California and southern strawberries, in the Chicago area, 1966-69*

Market channel and year	Nature of market loss				Total sampled
	Parasitic	Non-parasitic	Physical	Total	
	Percent	*Percent*	*Percent*	*Percent*	*Pounds*
Wholesale:					
1966	1.2	0.8	9.5	16.5	145
1967	3.3	1.6	7.5	12.4	213
1968	3.6	3.4	9.9	16.9	308
1969	2.4	1.1	7.2	10.7	179
1966-69	2.7	2.1	8.7	13.5	845
Retail:					
1966	3.1	.0	9.7	12.8	374
1967	1.5	.3	3.3	5.1	1,346
1968	1.5	[1] T	3.8	5.3	3,927
1969	.8	[1] T	3.1	3.9	1,398
1966-69	1.5	.1	3.9	5.5	7,045
Consumer:					
1966	8.2	.5	20.1	28.8	85
1967	2.7	1.1	13.9	17.7	117
1968	3.5	2.0	19.8	25.3	192
1969	1.7	.4	11.9	14.0	66
1966-69	3.9	1.3	17.0	22.2	460

[1] Trace.

TABLE 16.—*Relationship of market losses, derived by weight, from diseases and defects of California and southern grown strawberries, in the Chicago area, 1966-69*

Specific defects by category	Loss relationships of market levels		
	Wholesale	Retail	Consumer
	Percent	*Percent*	*Percent*
Parasitic:			
Gray mold rot	76	88	85
Rhizopus rot	16	4	7
Leather rot	3	5	3
Alternaria rot	[1] T	[1] T	0
Anthracnose	0	0	[1] T
Cladosporium rot	T	T	[1] T
Rhizoctonia rot	3	4	4
Powdery mildew	2	[1] T	[1] T
Category relationship [2]	25	27	17
Nonparasitic:			
Green fruit	46	61	64
Sunscald	3	[1] T	2
Catface	7	[1] T	6
Slug damage	44	39	28
Category relationship	14	2	6
Physical:			
Soft, bruised, cut or leaking	100	100	100
Category relationship	61	71	77

[1] Trace.

[2] Ratio of parasitic to nonparasitic to physical losses for each designated marketing level.

Auxiliary observations of acidity and soluble solids for April, July, and September of the test seasons revealed pH 3.29, pH 3.70, and pH 3.30; and 7.2, 9.5, and 8.5 percent, respectively. The mean for the season was pH 3.40 and 8.7 percent soluble solids.

Retail losses

Retail waste was 5.5 percent with physical damage contributing 3.9 percent. Parasitic disease, largely gray mold rot and nonparasitic disorders primarily green fruit, contributed 1.5 and 0.1 percent.

Consumer losses

The physical damage category continued its dominance in strawberry losses causing 17.0 of the 22.2 percent of the consumer loss. Parasitic disease, largely gray mold rot, contributed 3.9 percent, while nonparasitic problems dominated by green fruit caused 1.3 percent.

Discussion

Physical injury led at all levels and for each season, attributed largely to overmature berries. With a swiftly maturing fruit, this is a constantly vexing problem complicated by the time and distances involved in the shipment of the Western fruit to markets in the Midwest and East. Full-colored fruit should not be shipped and postharvest temperatures should be lowered promptly to below 40° F with every effort made to maintain that environment throughout the marketing period. Air express is a distinct advantage for this highly perishable commodity. This advantage, however, is negated by unrefrigerated loading delays. Correction of this situation should result in reduced strawberry waste (*5, 6, 15, 19*).

Parasitic disease loss in strawberries was consistently second throughout the study. Within this category, no pathogen or combination approached gray mold rot as a parasitic loss source.

Green berries dominated the nonparasitic category. Present throughout the study, green berries showed a gradual rise as the season progressed. Consistently next was a persistent damage of California-grown berries characteristic of that caused by slugs or snails although insects may have been involved.

Strawberry losses recorded at the wholesale and consumer levels should be considered as being close to maximum. Rules of the survey dictated discarding the entire berry; at the consumer level, particularly, many affected fruits could have been partially salvaged through trimming. The presence of cuts and bruises at the wholesale level, however, presented the spectre of decay before completing the market movement.

The actual retail loss from strawberry culling is reduced by the generous field fill of the flats, which usually more than compensated for discards.

Terminal Market Grade Certificate Survey

A supplemental study determined the deterioration that might be expected during transit of items studied. For this purpose, a survey was made of the Grade certificates issued by the U.S. Department of Agriculture, Fresh Products Standardization and Inspection

Division (FPS&I), Chicago. Neither those certificates issued for assessment of condition only, nor those covering lot (unload) inspections were included since it was felt that both favored bad order shipments. Although the condition (normally decay) was noted on the grade certificates as a factor of grade, the emphasis inferred is on the presence of those defects specifically related to grade (normally defects which do not advance during transit).

For grade determination, the FPS&I's inspectors use a detailed and formalized inspection procedure; no attempt was made to directly relate percentages to those of the market survey. The percentages noted on table 17 were obtained by dividing the sum of the average defect percentages by the number of certificates examined.

The results show a dominance of the physical damage to peaches, red potatoes, and strawberries, a trend paralleling the market survey at wholesale—the market channel most closely related in point of time. The certificate survey, however, revealed higher percentages of physiological defects for oranges (mostly rind breakdown), lettuce (mostly tipburn), and apples (mostly internal breakdown); all factors vital to the establishment of grade.

In the market survey reported here, however, rind breakdown was not scored unless quite severe, tipburn of lettuce contributed little to market loss on a weight-loss basis, and wholesale apples were not normally subject to internal examination, except during the first season of the wholesale survey. Here apples were cut to compare with consumer losses and revealed the same dominance of internal breakdown noted in the terminal inspection results.

The defects dominating the parasitic disease (DK), physiological disorders (PL), and physical damage (PD) categories as revealed by the certificate search were as follow:

Apples — (DK) - unspecified, (PL) - internal breakdown, scald, and water core, (PD) - bruising;

Lettuce — (DK) - bacterial soft rot, (PL) - tipburn, (PD) - broken midribs;

Navel oranges — (DK) - green mold rot, (PL) - rind breakdown, (PD) - crushing;

Valencia oranges — (DK) - unspecified, (PL) - rind breakdown, (PD) - none;

Peaches (southern) — (DK) - brown rot, (PL) - none, (PD) - bruising;

Red potatoes (Red River Valley) — (DK) - Fusarium and other decays, (PL) - internal black spot, (PD) - bruising;

Potatoes (California long white) — (DK) - unspecified, (PL) - internal black spot and scald, (PD) - bruising;

Strawberries (California) — (DK) - gray mold rot and Rhizopus rot, (PL) - none, (PD) - soft or leaking berries or both;

Strawberries (southern) — (DK) - gray mold rot and Rhizopus rot, (PL) - none, (PD) - soft or leaking berries or both.

TABLE 17.—*Defects of selected fruits and vegetables from USDA terminal grade inspection certificates, Chicago area, 1966-69*

Product	Nature of loss			Total	Number of certificates examined
	Parasitic	Nonparasitic	Physical		
Apples:	*Percent*	*Percent*	*Percent*	*Percent*	
Northwest Red Delicious	0.7	6.3	2.8	9.8	40
Lettuce:					
California head	3.7	12.4	1.6	17.7	720
Oranges:					
California Navel	1.8	5.4	.2	7.4	32
Florida Valencia	3.7	6.9	.0	10.6	18
Peaches:					
Southern and eastern	2.9	.0	7.5	10.4	106
Potatoes:					
Red River Valley red	1.8	.6	3.0	5.4	165
California long white	2.5	3.5	1.5	7.5	268
Strawberries:					
California	10.7	2.1	13.3	26.1	19
Southern	6.3	3.7	12.7	22.7	3

The importance of the control of postharvest condition factors is illustrated by the finding that with condition as a factor of grade, failure to make grade ranged from 51 (peaches) to 100 percent (southern strawberries) with the average failure of all items surveyed being 72 percent.

Failure to make grade because of grade factors alone ranged from none (apples, Valencia oranges, peaches, and strawberries) to 13 percent (lettuce); the average for all items studied was 3 percent.

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